March 30, 1965 A. L. COSTAKIS 3,175,813

EDGE POSITION CONTROL OF STRIP MATERIAL IN FURNACES

Filed Dec. 31, 1962 3 Sheets-Sheet 1

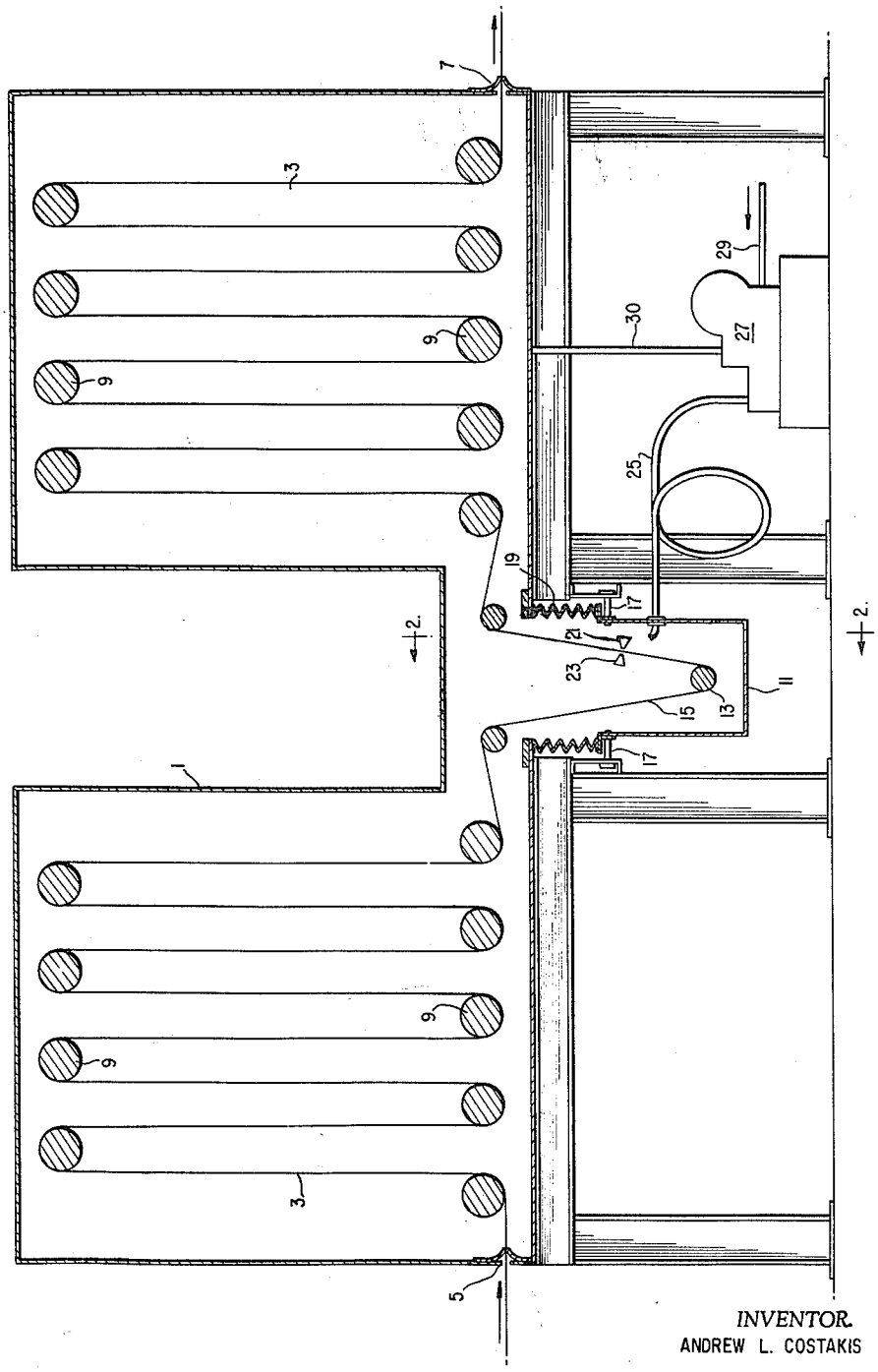


FIG. 1

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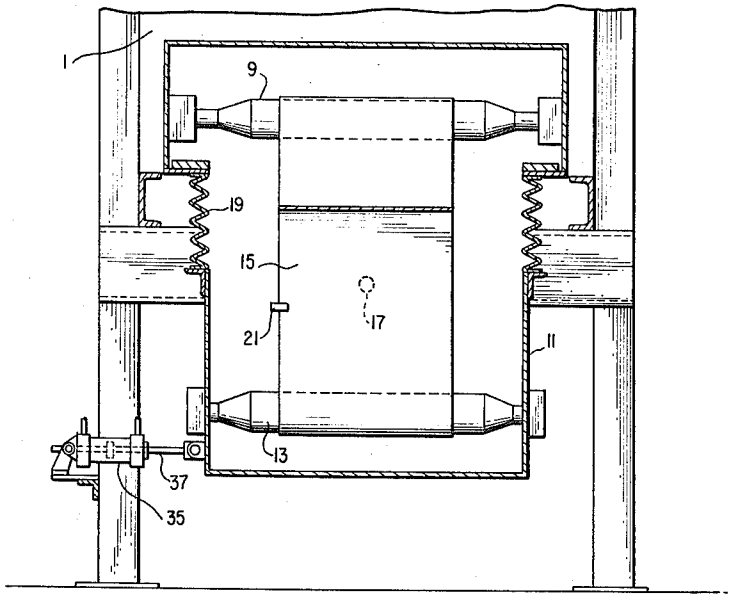
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FIG. 2



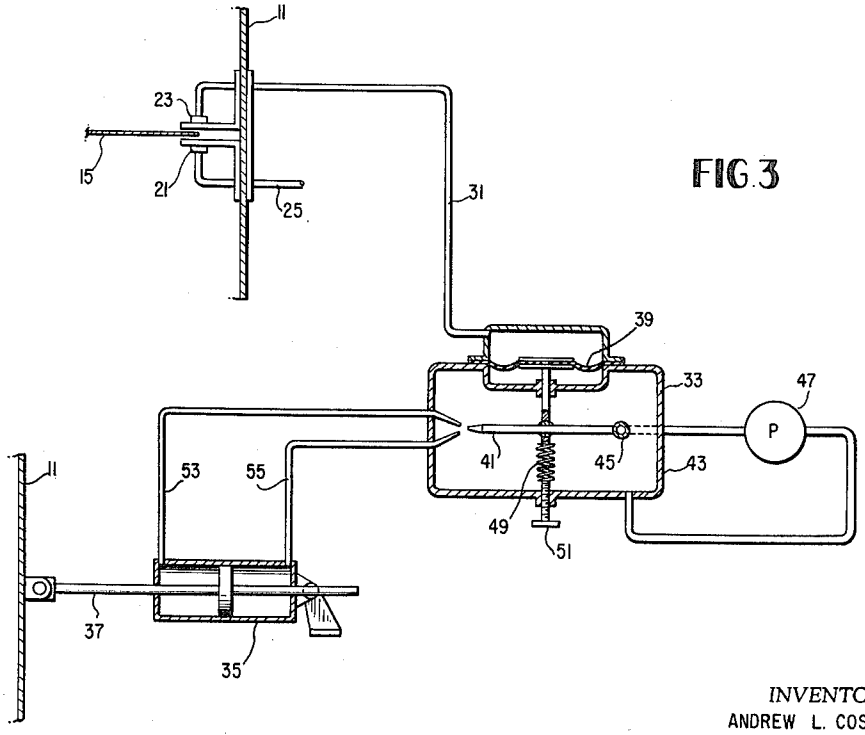


FIG. 3

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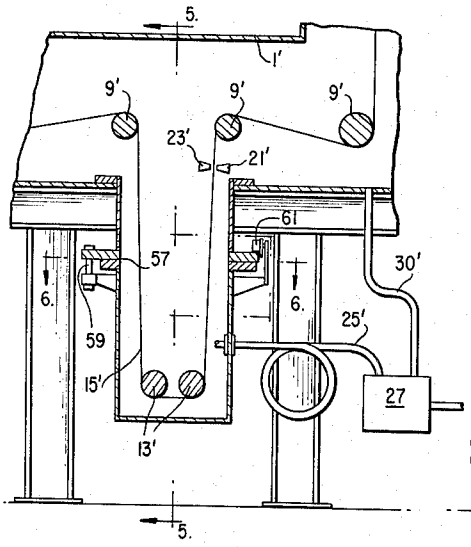


FIG. 4

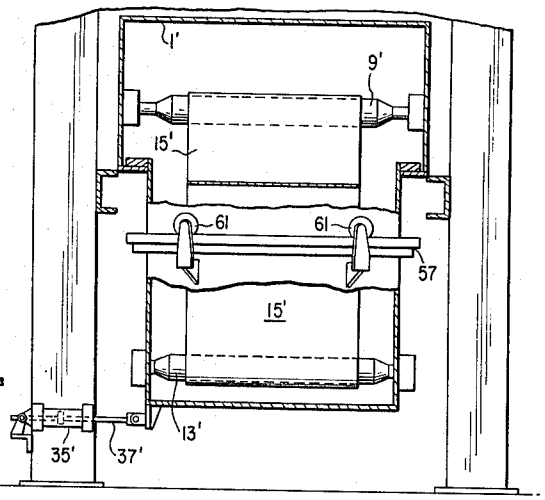
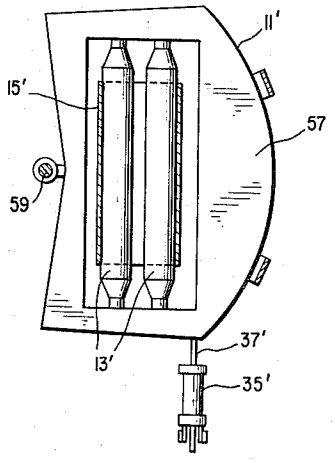


FIG. 5

FIG. 6



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EDGE POSITION CONTROL OF STRIP MATERIAL IN FURNACES

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18 Claims. (Cl. 263—3)

The present invention relates to apparatus for controlling the position of the edges of strip material in furnaces.

In the feeding of indeterminate lengths of strip material over rolls, various factors tend to cause the strip to move toward one end or the other of the rolls and thus to become misaligned relative to the rolls. A number of systems for correcting this positional error of the strip have been proposed and many are quite useful in ordinary operations. But in the environment of a furnace which is entirely enclosed in order to conserve heat or to maintain an inert atmosphere to prevent oxidation of the strip, the ordinary devices for controlling the position of the strip are unavailable for use because the rolls are entirely within the furnace. If it is attempted to use a self-centering roll or a crowned roll or other type of roll which by its physical configuration tends to center the strip, it is found that such devices are not really effective because they do not center the strip when one side of the strip is under a different tension from the other side of the strip.

Accordingly, it is an object of the present invention to provide apparatus for centering strip on rolls while the strip is passing through a furnace of the type that encloses a plurality of rolls about which the strip passes in a circuitous path.

Another object of the invention is the provision of such apparatus that will be relatively simple and inexpensive to manufacture, install, operate, maintain and repair, and rugged and durable in use.

Other objects and advantages of the present invention will become apparent from a consideration of the following description, taken in connection with the accompanying drawings, in which:

FIGURE 1 is a schematic elevational view, with parts broken away, of one embodiment of a furnace according to the present invention;

FIGURE 2 is a fragmentary cross-sectional view taken on the line 2—2 of FIGURE 1;

FIGURE 3 is a diagrammatic view of a strip edge position detector and regulator and control mechanism in accordance with one embodiment of the invention;

FIGURE 4 is a fragmentary elevational view similar to a portion of FIGURE 1 but showing a modified form of the invention;

FIGURE 5 is a view taken on the line 5—5 of FIGURE 4; and

FIGURE 6 is a view taken on the line 6—6 of FIGURE 4.

Referring now to the drawings in greater detail, and with reference first to the embodiment of FIGURES 1–3, there is shown in FIGURE 1 a furnace comprising an enclosure 1 through which strip material 3 such as steel strip to be treated at elevated temperature passes in a circuitous path between an entrance 5 and an exit 7 of the furnace enclosure about a series of rolls 9 that bend the strip material into a plurality of loops or bights to assure that the strip material will have a sufficiently long residence time in the furnace to enable the heat treatment in question to be carried out.

The structure of the furnace may be generally conventional apart from the present invention and may include the usual heating means (not shown). The term "furnace" as used herein includes not only enclosures that raise the temperature of material, but also enclosures that are designed to maintain raised temperatures or to retard the cooling of material which is at elevated temperature, as well as enclosures that are designed to maintain an inert atmosphere about material at elevated temperature so as to avoid oxidation of the material resulting from contact between the hot material and the oxygen of the air.

The present invention includes novel structure in the form of an extension 11 to the enclosure of the furnace, that is spaced between entrance 5 and exit 7 and that extends laterally from the rest of enclosure 1 so that it is accessible from several sides. A steering roll 13 is mounted in extension 11 on and between the side walls of the extension for rotation about its axis relative to the extension but for bodily movement conjointly with the extension. Roll 13 is shown in FIGURE 1 as a single roll; but it may instead take the form of a plurality of rolls mounted for rotation in extension 11 on parallel axes. The strip material 3 is reeved about roll 13 to form a loop 15 that extends laterally away from the rest of enclosure 1 in the same direction as extension 11.

An important feature of this invention is that roll 13 be movable relative to a plurality of rolls 9 ahead of it and after it with respect to the direction of strip movement, between first and second positions characterized in that the axis of roll 13 in the first position is disposed at an acute angle to the axis of roll 13 in the second position. Preferably, the axis of roll 13 in one of the positions through which roll 13 is movable is parallel to the axes of the other rolls 9 in the enclosure. Roll 13 may thus be swingable in a vertical plane about a horizontal axis that passes through the axis of roll 13, or in a horizontal plane about a vertical axis that passes through the axis of roll 13, or in some plane intermediate those vertical and horizontal planes, or about an axis spaced from the axis of roll 13. In the illustrated embodiments, the axis of the roll is perpendicular to and intersects or else is spaced from the axis of turning movement of the extension. Such movement of roll 13 from parallelism to the other rolls 9, as is well known, will cause the strip to move laterally toward one end or the other of roll 13 depending on the direction in which roll 13 is swung.

Another important feature of the invention is that roll 13 is mounted on extension 11 for bodily movement with extension 11, and that at least a portion of extension 11 is mounted for movement relative to the rest of enclosure 1. In the embodiment of FIGURE 1, extension 11 is supported on and for vertical swinging movement about the common axis of a pair of opposed trunnions 17 that are mounted on brackets that depend from the furnace frame and that swingably support extension 11 adjacent the top of extension 11. A bellows seal 19 extends between and interconnects the stationary portion of enclosure 1 with the upper end of relatively movable extension 11 thereby substantially to seal between extension 11 and the rest of enclosure 1 but at the same time to permit extension 11 to have limited movement relative to enclosure 1.

Still another very important feature of the invention is the provision of detector means for determining when the strip material has become so misaligned as to require movement of extension 11 in such a direction as to incline roll 13 sufficiently to cause the strip material to correct its position on the rolls. The detector specifically illustrated in the drawings is of the type in which a stream of gas moves adjacent the edge of the strip and is cut off from free flow to a greater or lesser extent according to the position of the edge of the strip. The quantity of gas passing the edge of the strip is thus a function of the position of the edge of the strip; and means are provided responsive in degree to the quantity of gas passing the edge of the strip to swing roll 13 in a direction and by an

amount sufficient to return the edge of the strip to a desired predetermined position corresponding to a centered position of the strip on its associated rolls adjacent the detector. To this end, as is best seen in FIGURE 3, there is provided a supply nozzle 21 mounted on the inner side of extension 11 for directing a stream of gas on both sides of the edge of the strip and normal to the strip, that is, with a portion of the directed stream of gas impinging on the edge of the strip and another portion of the directed stream of gas missing and passing the edge of the strip. An opposed recovery nozzle 23 within extension 11 on the opposite side of the strip edge is provided for receiving and transmitting the pressure of the supply stream in a magnitude proportional to the quantity of the supply stream that passes the strip edge.

In order to supply gas under pressure to the supply nozzle, a flexible conduit 25 is provided that interconnects the supply nozzle with the higher pressure stage of a plural stage compressor 27. Supply nozzle 21 is preferably fixed relative to extension 11; but flexible conduit 25 makes it possible for extension 11 to move relative to compressor 27. Compressor 27, in turn, withdraws inert gas from a supply of inert gas (not shown) through a supply conduit 29 and increases its pressure to the pressure of the output of the higher pressure stage of the compressor. The gas is inert so as to prevent oxidation of the strip material at the elevated temperature of the furnace. Compressor 27 thus performs the dual function of maintaining enclosure 1 under a positive pressure of inert gas slightly above atmospheric, so as to prevent the ingress of any oxygen-bearing air, and also the function of supplying an inert gas for the strip edge detector. A return conduit 30 returns excess inert gas from the interior of enclosure 1 at a superatmospheric pressure lower than the outlet pressure in conduit 25 but higher than the intake pressure in conduit 29, to an intermediate stage of compressor 27 for recompression and recycle and re-use.

The quantity of inert gas passing the edge of the strip material is determined by the pressure downstream of recovery nozzle 23; and this pressure, in turn, is transmitted by a flexible conduit 31 to a regulator 33 which controllably actuates a fluid motor 35 that acts through a link 37 to swing extension 11 about the axis of trunnions 17. Motor 35 is fixedly mounted relative to enclosure 1, and link 37 is urged by the piston of motor 35 to move extension 11 relative to motor 35. Regulator 33, on the other hand, may be either fixed relative to motor 35 or else movable with extension 11. If movable with extension 11, then conduit 31 need not be flexible. Instead, the conduits interconnecting regulator 33 with motor 35 in that latter instance would be flexible.

In greater detail, regulator 33 comprises a diaphragm 39 which is in fluid communication with conduit 31 so that increases or decreases in the pressure in conduit 31 brought about by changes in the position of strip material 3 will cause diaphragm 39 to move up or down. Diaphragm 39, in turn, swings a jet pipe 41 that is disposed within casing 43 of regulator 33 about a swivel joint 45. Jet pipe 41, in its turn, is supplied with oil or other hydraulic fluid under pressure from a pump 47 so that oil flows from pump 47 through swivel joint 45 and out through the left-hand end of jet pipe 41 as seen in FIGURE 3. A spring 49 within casing 43 continuously urges jet pipe 41 and diaphragm 39 in one direction; while an adjustment screw 51 adjustably regulates the compressive force in spring 49 so as to increase or decrease the degree to which jet pipe 41 swings upon pressure changes in conduit 31. Jet pipe 41 discharges against the open intake orifices, disposed within casing 43, of a pair of conduits 53 and 55 that communicate with opposite ends of the motor chamber of fluid motor 35, thereby to move the piston of the motor in one direction or the other depending on the position of jet pipe 41, that is, depending on which conduit 53 or 55 is receiving oil under pressure from pipe 41.

In operation, therefore, movement of strip material 3 to the left as seen in FIGURE 3 will permit more inert gas to blow between nozzles 21 and 23, which will raise the pressure in conduit 31 and force diaphragm 39 downwardly thereby aiming jet pipe 41 more at conduit 55 than at conduit 53, with the result that the piston of motor 35 will move to the left as seen in FIGURE 3, causing link 37 to swing extension 11 counterclockwise as seen in FIGURE 2. This counterclockwise movement increases the tension on the left side of strip material 3 as seen in FIGURE 2 thereby causing the strip to move to the left as seen in FIGURE 2, which is to the right as seen in FIGURE 3, until the strip is centered and pipe 41 is pointed between the intake orifices of conduits 53 and 55 and the piston of motor 35 does not move.

A somewhat modified form of the invention is shown in FIGURES 4–6, in which the same or substantially the same parts as in the preceding embodiment are indicated by primed reference numerals. In this second embodiment, the extension 11′ is movable relative to the rest of the enclosure 1′, but about a vertical axis rather than a horizontal axis. Specifically, extension 11′ meets the rest of enclosure 1′ in a horizontal continuous closed sliding seal 57 the two parts of which slide together substantially to seal between extension 11′ and the rest of enclosure 1′. Extension 11′ is mounted for horizontal swinging movement about a vertically disposed pivot pin 59 that is carried by and depends from the stationary or upper portion of seal 57. On the side of extension 11′ opposite pivot pin 59, extension 11′ carries a plurality of wheels 61 that rotate on horizontal axes and that ride on the upper surface of the upper or stationary portion of sliding seal 57. The steering rolls in this latter embodiment are in the form of a pair of rolls 13′ that swing bodily in a horizontal plane about the vertical axis of pivot pin 59 by virtue of the fact that they are journalled in opposite sides of extension 11′. This swinging movement of rolls 13′ causes the strip material to move toward one end or the other of the adjacent rolls 9′ in enclosure 1′, in a well-known manner. Motor 35′ and link 37′ thus exert their influence a substantial horizontal distance from the axis of pivot pin 59. Otherwise, the principles and operation of the invention in the embodiment of FIGURES 4–6 are the same as in the embodiment of FIGURES 1–3.

From a consideration of the foregoing disclosure, therefore, it will be obvious that all of the initially recited objects of this invention have been achieved.

Although the present invention has been described and illustrated in connection with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit of the invention, as those skilled in this art will readily understand. Such modifications and variations are considered to be within the purview and scope of the present invention as defined by the appended claims.

What is claimed is:

1. A furnace comprising an enclosure, a plurality of rolls within the enclosure for the support of continuously moving strip material as it passes through the enclosure in a circuitous path, means mounting at least one of the rolls for movement relative to a plurality of the other rolls between first and second positions characterized in that the axis of said at least one roll in said first position is disposed at an acute angle to said axis in said second position, said at least one roll being disposed ahead of at least one other roll and behind at least one other roll in the furnace relative to the direction of movement of the strip material, and means responsive to lateral misalignment of the strip material for moving said at least one roll to change the angle of its axis relative to the axes of others of the rolls in the enclosure thereby to correct the misalignment of the strip material.

2. A furnace as claimed in claim 1, the last-named

means including means in the enclosure for detecting a misaligned position of the strip material, and means outside the enclosure responsive to the detecting means for moving said at least one roll to correct the misalignment.

3. A furnace as claimed in claim 1, the mounting means comprising a portion of the enclosure, said portion having means to mount said portion for movement relative to the remainder of the enclosure.

4. A furnace as claimed in claim 3, said misalignment-responsive means including means in the enclosure for detecting a misaligned position of the strip material, and means outside the enclosure responsive to the detecting means for moving the movable enclosure portion thereby to effect sad roll movement to correct the misalignment.

5. A furnace as claimed in claim 3, and means substantially sealing between said relatively movable portion and the remainder of the enclosure.

6. A furnace as claimed in claim 5, the last-named means comprising a bellows seal.

7. A furnace as claimed in claim 5, the last-named means comprising a sliding seal.

8. A furnace comprising an enclosure having an entrance and an exit for continuously moving strip material, a plurality of rolls within the enclosure for supporting the strip material as it passes through the enclosure in a circuitous path from the entrance to the exit, the enclosure having an extension spaced between the entrance and the exit, at least one of the rolls being disposed in and carried by the extension to form a loop of strip material within the extension, means mounting said at least one roll for movement relative to rolls outside the extension between first and second positions characterized in that the axis of said at least one roll in said first position is disposed at an acute angle to said axis in said second position, and means responsive to lateral misalignment of the strip material for moving said at least one roll to change the angle of its axis relative to the axes of rolls outside the extension thereby to correct the misalignment of the strip material.

9. A furnace as claimed in claim 8, the last-named means including means in the enclosure for detecting a misaligned position of the strip material, and means outside the enclosure responsive to the detecting means for moving said at least one roll to correct the misalignment.

10. A furnace as claimed in claim 8, the mounting means comprising at least a portion of the extension, said at least a portion having means to mount said at least a portion for movement relative to the remainder of the enclosure.

11. A furnace as claimed in claim 10, said misalignment-responsive means including means in the enclosure

for detecting a misaligned position of the strip material, and means outside the enclosure responsive to the detecting means for moving the movable extension portion thereby to effect said roll movement to correct the misalignment.

12. A furnace as claimed in claim 10, and means substantially sealing between said relatively movable extension portion and the remainder of the enclosure.

13. A furnace as claimed in claim 12, the last-named means comprising a bellows seal.

14. A furnace as claimed in claim 12, the last-named means comprising a sliding seal.

15. A furnace comprising an enclosure, means for maintaining an atmosphere of inert gas within the enclosure, a plurality of rolls within the enclosure for the support of continuously moving strip material as it passes through the enclosure in a circuitous path, means mounting at least one of the rolls for movement relative to a plurality of the other rolls between first and second positions characterized in that the axis of said at least one roll in said first position is disposed at an acute angle to said axis in second position, said at least one roll being disposed ahead of at least one other roll and behind at least one other roll in the enclosure relative to the direction of movement of the strip material, means within the enclosure adjacent said at least one roll for directing a stream of inert gas substantially normal to the strip material with at least a portion of the stream of inert gas impinging on an edge of the strip material, and means responsive to the quantity of inert gas that passes said edge for moving said at least one roll to change the angle of its axis relative to the axes of others of the rolls in the enclosure thereby to correct the misalignment of the strip material.

16. A furnace as claimed in claim 15, the last-named means being disposed outside the enclosure.

17. A furnace as claimed in claim 15, the mounting means comprising a portion of the enclosure, said portion having means to mount said portion for movement relative to the remainder of the enclosure.

18. A furnace as claimed in claim 17, and conduit means passing through the enclosure and interconnecting said directing means and said responsive means, the conduit means having a flexible portion between the enclosure and said responsive means.

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